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ABSTRACT

The objective of this project was to develop a way of producing instructional materials such that once an acceptable design had been achieved, hypermedia documents could be easily generated with no additional programming or design effort. The project was undertaken to support a case-based instructional curriculum in medical education. Southern Illinois University offers a Problem-Based Learning (PBL) curriculum as an alternative to the traditional first 2 years of medical school; students within the PBL curriculum work in small teams addressing a series of clinical cases. Over the 2-year course of the curriculum, students encounter about 100 clinical teaching cases. In the computer-based implementation of a teaching case, called an MMT, the case is presented as a hypermedia document. MMTs are divided into sections related to a clinical encounter. As a presentation interface, the design of the MMT has three main features: navigating among sections of the case, selecting individual data items within a section, and displaying available resources for a data item. The means by which students select individual items within a section of the MMT is designed to support an authentic process of inquiry. MMTs are implemented as a set of HyperCard stacks--each section of the case is implemented as an individual stack; within each stack, data items are presented on separate cards. After the hypermedia document had been developed and evaluated, it can be used as a prototype to create additional documents; the format remains the same for each subsequent document but the contents change without affecting usability. Automatic generation of multimedia documents is also useful for usability evaluation. Three figures illustrate components of an MMT. (AEF)

Hypermedia without Programming: Automatic Generation of Presentation Documents for Case-based Instruction

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paper

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There is growing interest in methods of instruction which are based upon problem-solving cases drawn from real-world practice (Koschmann, 1994; Williams, 1992). One of the major impediments to implementing case-based curricula, however, is the scarcity of published teaching materials. Educators interested in introducing curricula of this kind must often produce their own materials, unlike the diverse offerings made available by the textbook industry for more traditional methods of instruction. To address this curricular need, some institutions have begun to produce hypertext and hypermedia representations of teaching problems. Often these computer-based methods of presentation are more compelling for students to use and are less labor-intensive to produce than paper-based materials (Koschmann, Myers, Feltovich, & Barrows, 1994).

Though it may be less labor intensive than generating a text, producing hypermedia teaching cases still involves a lot of work. Further, the people charged with doing curricular development may not necessarily possess the special technological skills required to construct hypermedia materials. A development team might include graphic artists, programmers, domain specialists, and human factors engineers. An important part of this development includes usability evaluations to ensure that the materials are easy for students to use and understand. The objective of this project, therefore, was to develop a way of producing instructional materials such that once an acceptable design had been achieved, hypermedia documents could be easily generated with no additional programming or design effort.

MMT: A Hypermedia Case Presentation Document

The current project was undertaken to support a case-based instructional curriculum in medical education. Southern Illinois University offers a Problem-Based Learning (PBL) curriculum as an alternative to the traditional first two years of medical school (Barrows, 1994). Students within the PBL curriculum work in small teams (usually six students and a faculty "coach") addressing a series of clinical cases. Over the two-year course of the curriculum, students encounter about 100 clinical teaching cases.

All of the teaching cases have a common structure. Students are given the circumstances that led the patient to seek medical attention (i.e., the "presenting situation"). They must then "work up" the case by generating questions to ask the patient, selecting examination items, and requesting test and laboratory results. In the past this was done using a paper-based representation of the case, termed a PBLM, in which each data item (i.e., interview response, examination item, laboratory test) appears on a separate page (Distlehorst & Barrows, 1982). When the students wish to see a particular data item, they are given the page number in the PBLM and the result is read to the group.

In the computer-based implementation of a teaching case, which we term an MMT, the case is presented as a hypermedia document. MMTs are logically divided into sections related to a clinical encounter: patient interview, physical examination, and requested laboratory tests. As a presentation interface, the design of the MMT has three salient features—navigating among sections of the case, selecting individual data items within a section, and displaying available resources for a data item.

As shown in Figure 1, individual data cards have page tabs near the bottom of the window enabling users to navigate among sections of the document. These tabs operate like radio buttons allowing the student to move from one section to another. In the Interview section, students ask the patient questions; in the Examination section, students describe a physical examination to be performed; in the Test section, students describe a laboratory test to be performed. By structuring the document in this way, the student is provided with a logical way of dividing the components of a clinical work-up, one that is consistent with clinical practice.

The means by which students select individual items within a section of the MMT is designed to support an authentic process of inquiry (Barrows, 1990; Koschmann, et al., 1994). For example, students might enter a 'question' in the Doctor's Question field to illicit information from the patient. The program compares the request against possible responses within the current section. We term this approach *pattern-matching within a bounded context*. If an appropriate response is found then the information is displayed; otherwise, the user is prompted to try another request. This strategy has two instructionally important features: students must inquire all information and there is no queuing. Just as in a real clinical situation, students must generate their own questions without any help.

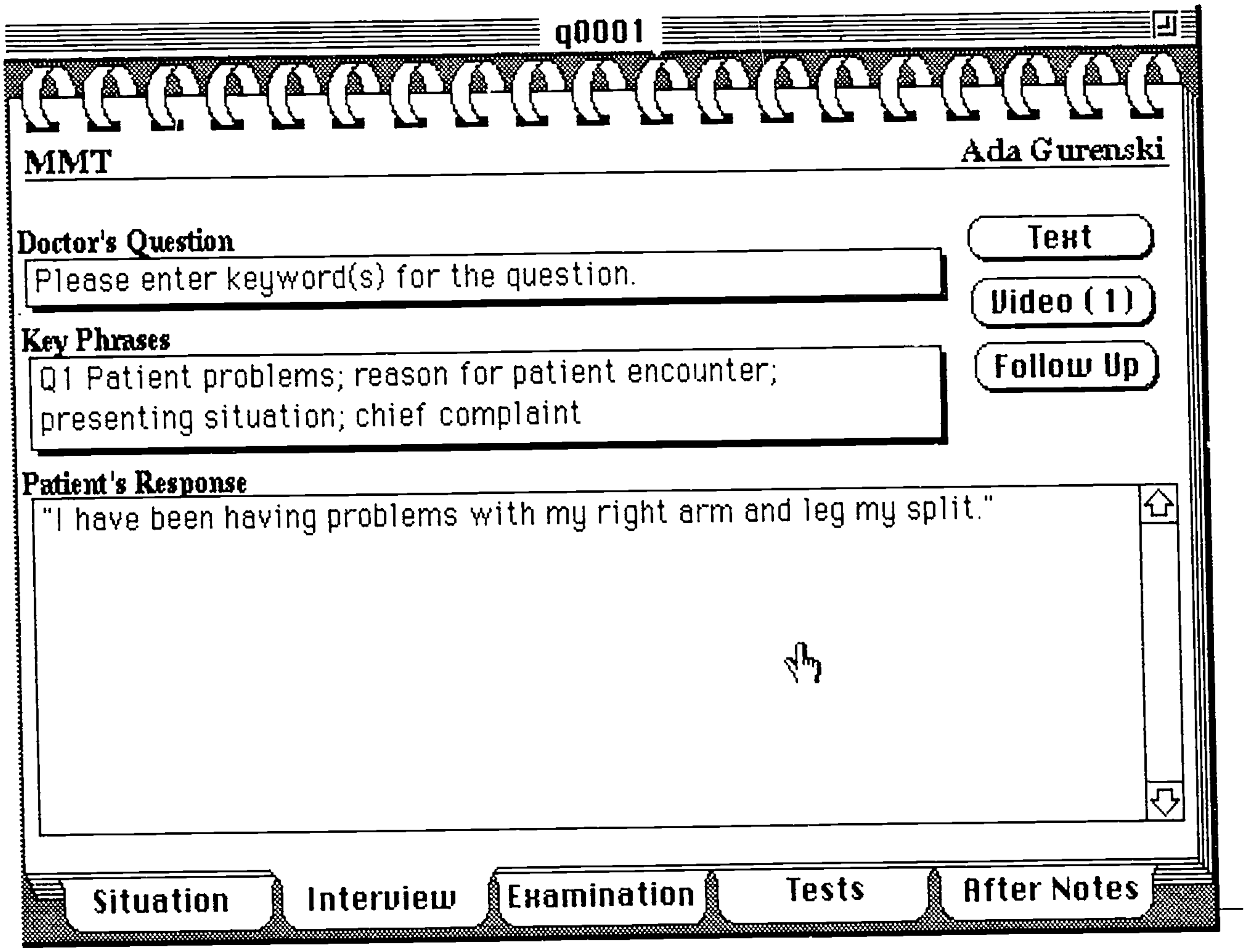

Figure 1. MMT data card.

Learning is also facilitated by the way available data, called *resources*, are presented. As shown in Figure 1, resources are selected using buttons that appear on the right side of the data card. A "Text" resource displays a textual response to the question. A "Video" resource contains one or more video segments to be played on an attached monitor. A "Consult" resource displays a specialist's interpretation of a test result. A "Normals" resource displays normal laboratory values for the current test result. A "Follow-Up" resource allows students to explore a symptom in greater depth (e.g., When did *it* begin? What makes *it* worse? What makes *it* better?). The division of the results into multiple resources was designed to facilitate group deliberation and to allow more opportunities for group discussion. For example, after looking at a test result for this patient (with the Text button) students might have a discussion about the range of normal values for this particular test before referring to the Normals resource.

The Teaching Case Library

PBLMs, the paper-based version of the teaching cases, are produced using word processing files—every case stored in a separate file. This makes it difficult to maintain the library of teaching cases, especially as the library grows. For example, searching through files seeking cases with particular data values is extremely cumbersome. Further, even though some data is common to all cases (e.g., the price of various diagnostic tests), it is stored redundantly in each teaching case file. A change to the common data must be made in each file instead of a central location.

For generating MMTs, we needed to design a common repository for case-related data (Koschmann, et al., 1994). This repository, which we term the Teaching Case Library (TCL), is implemented using a commercial, relational database management system. The structure of this database is shown in Figure 2.

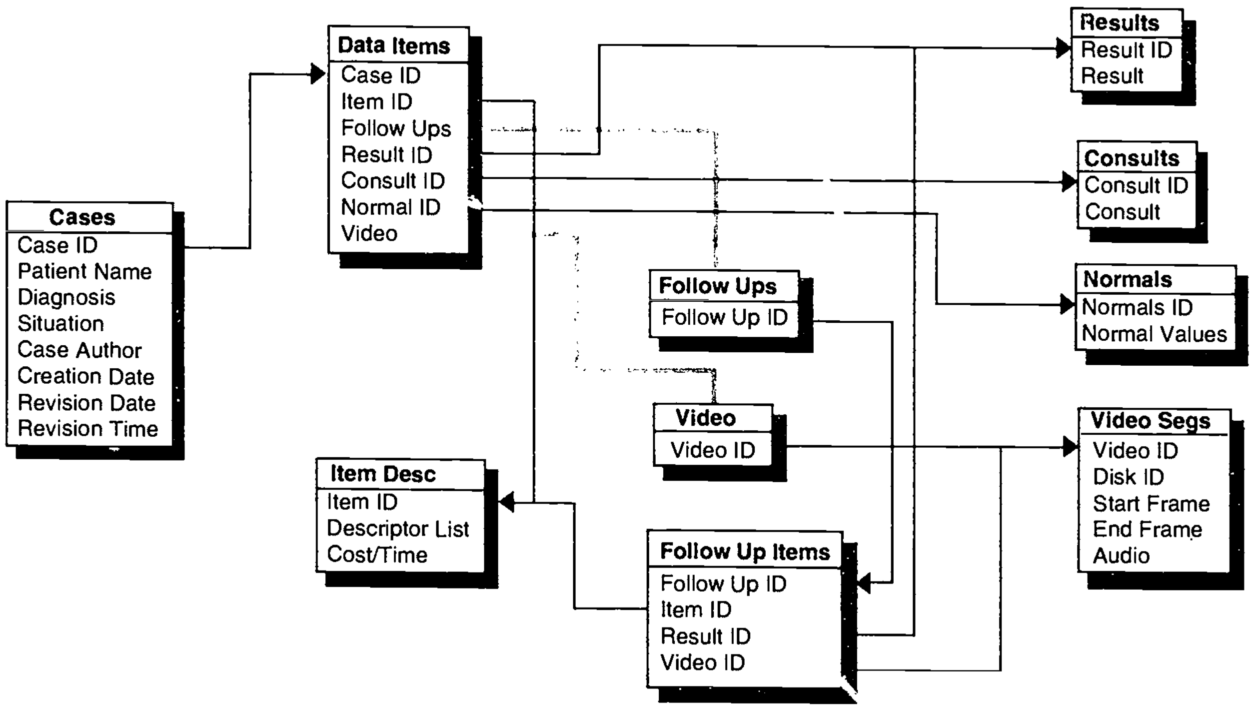

Figure 2: Structure of the Teaching Case Library.

Information pertaining to a teaching case is distribu' ·d across several data files. At the top level is global information pertaining to the whole case (e.g., patient name, patient age, presenting situation). Linked to the case record by the Case ID are a large number of data item records representing interview responses, examination results, and laboratory data. A set of descriptors is maintained for every possible data item in the Item Description data file. Data items may have one or more video segments or follow ups associated with them. Each of the data item records may have a number of resources associated with it as described previously for MMT data cards. For example, textual results for a data item are stored in the Results data file, specialist interpretations are stored in the Consults data file, laboratory normals are stored in the Normals data file, and individual video segments are stored in the Video Segs data file.

To produce teaching cases for student use, data records for a particular case must be selected, joined, and exported. As shown in Figure 3, cases can be presented to the students as an MMT or as a PBLM. In the next section we will look at the process for generating MMTs.

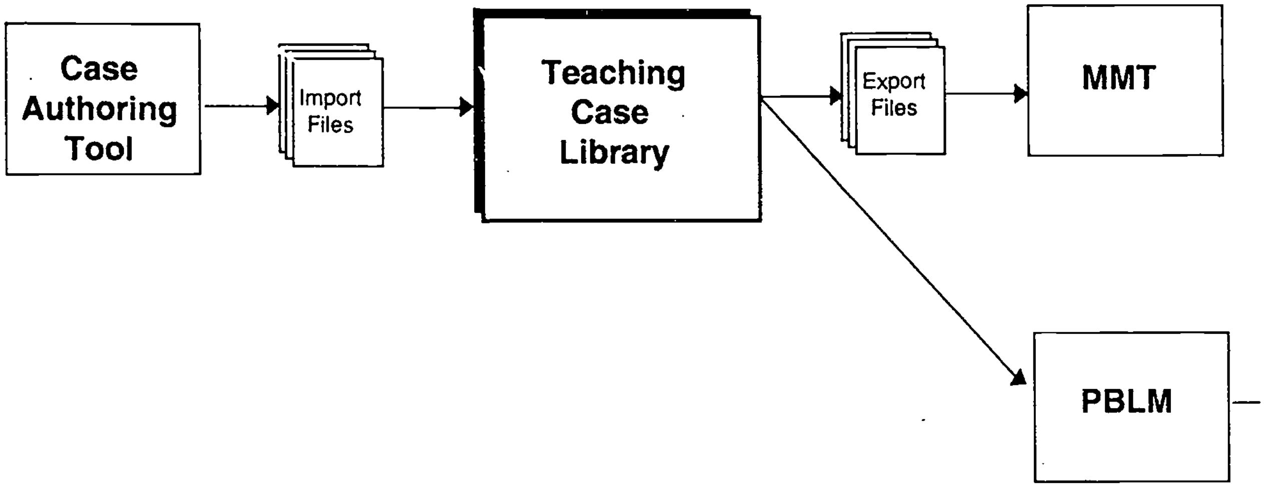

Figure 3: Data flow among the programs used to produce an MMT.

Automatic Generation of Documents

Considerable time and expertise is required to develop effective hypermedia documents. However, after the document has been developed and evaluated, it can be used as a prototype to create additional documents easily. The format remains the same for each subsequent document but the contents change without affecting usability. This strategy is ideal for production environments responsible for generating a large number of case documents that share the same format.

MMTs are implemented as a set of HyperCard stacks—each section of the case (e.g., interview, examination, tests) is implemented as an individual stack. Within each stack, data items (i.e., interview question, examination item, laboratory test) are presented on separate cards. An export file is produced by the TCL database management system for each section. For instance, there is an export file that contains data pertaining to the patient interview. The file contains some identifying information in a header record and then a large number of similarly structured records, each corresponding to a single data item. All information is stored as simple text that can be processed easily by other applications.

To produce an MMT, we start with a set of *Builders*— special stacks that expand and duplicate themselves. We developed a simple procedure that reads information from an export file and automatically builds a stack. Each Builder contains one or more prototype cards. A *prototype card* contains all of the fields and buttons to be used in the new stack. As the Builder reads each record in the export file, it duplicates a prototype card and fills the new card fields with data. This creates a collection of new cards that form the stack. This process is repeated with each of the export files to produce a set of stacks that constitute an MMT.

The building process can be quite sophisticated by copying buttons *only if they are needed*. For example, MMT uses videodisk technology. Cards that contain video information must have a "Play Video" button. Cards that do not have video information should not have a video button. We use a flag in the export file to indicate whether the Builder should include a particular button on the current card. This strategy can be extended to include optional images, sound, and video for each card based on flags in the intermediate file. Cards can take on different appearances depending on their content.

Conclusions

Automatic generation of teaching documents is part of a deliberate strategy to isolate the development of case content from the production of the presentation format. Previously these processes were combined, resulting in a great loss of flexibility. Using the procedure currently under development, new presentation formats can be easily implemented providing an environment that encourages experimentation. This strategy, though it lends itself particularly well to the production of materials for case-based instruction, could be useful in any setting with a high degree of structural similarity in the final product.

One potential application is a generic storybook. A prototype would be developed by experts that includes shared information and navigation buttons for a particular storybook style. Authors can then write original stories in a suitable format with a standard word processor. The resulting text document is used by a Builder to generate 'original' hypermedia documents. This strategy would allow grade school children to create their own sophisticated hypermedia documents without any programming or graphic design skills.

Automatic generation of multimedia documents is also useful for usability evaluation. Usability evaluation is an importat phase of software development (Hix and Hartson, 1993). Builders allows a developer to separate the look and feel of a hypermedia document from its content. Once the content has been standardized, user interface features such as appearance and navigation can be designed. This capability is ideal for usability evaluation experiments. Different versions of the same document can be created for an empirical evaluation. Document content is an independent variable and interface features are highly controlled dependent variables. For example, our original version of MMT uses a variety of buttons to navigate and make selections. We plan to develop an alternative interface that uses pull down menus instead of buttons. When we compare the two presentation formats for effects on learning, we will know that the document *content* is not a confounding factor. Given a properly controlled experiment, any observed differences will be due to the presentation format.

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